INTRODUCTION

The purpose of Section 316(b) of the Clean Water Act is to regulate the impact of cooling water intake structures on aquatic life (fish and shellfish) caused by impingement and entrainment. Facilities with such structures are overwhelmingly stream electric generation plants. Over the past few years, the U.S. Environmental Protection Agency (EPA) has been developing new regulations to implement this statute pursuant to various consent decrees entered in United States District Court, Southern District of New York. The Section 316(b) rulemaking process has three phases. The first phase, finalized on Dec. 17, 2001, promulgated rules for new facilities that will require new or expanded intake structures; the design intake rate will be greater than 2 million gallons per day (MGD). Phase II regulations, which are for existing facilities with intake rates greater than 50 MGD, were finalized on Feb. 16, 2004. Regulations for existing facilities with intake rates less than 50 MGD (Phase 3) will follow. Documentation demonstrating compliance with the new Section 316(b) regulations will have to be included with a facility’s application for a new or renewed discharge permit issued under the National Pollutant Discharge Elimination System (NPDES).

PHASE II RULES

Existing power plants have several options to achieve compliance with the Phase II rules:

- reduce cooling water design intake rates commensurate with closed-cycle, recirculating cooling systems - achieves compliance for minimizing impingement and entrainment
- reduce intake trough-screen velocity to no more than 0.5 feet per second (fps) – achieves compliance for minimizing impingement but not entrainment
- use technological, operational, or mitigation measures that meet national performance standards for reducing impingement mortality and entrainment
- install an approved design and construction technology – e.g., a fine-mesh, cylindrical, wedge-wire screen with a through-screen no more than 0.5 fps
- use technological, operational, or mitigation measures that are determined to be the best technology based on site-specific criteria

The national performance standards are an 80 percent to 95 percent reduction in impingement mortality and a 60 percent to 90 percent reduction in entrainment. These reductions are relative to the Calculation Baseline, which is a site specific estimate of impingement mortality and entrainment from a hypothetical, shoreline, cooling water intake for once-through cooling that has a standard ¾-inch mesh traveling water screen but no specific controls for reducing impingement and entrainment. Other specifications of the hypothetical intake, such as design intake rate and through-screen velocity, are the same as the actual intake.

The performance standards applicable to a given facility depend on the capacity factor of the power plant, the source of the cooling water, and the proportion of the source water withdrawn. Facilities with a capacity factor of 15 percent or less are subject only to the impingement mortality standard. Power plants that withdraw more than 5 percent of the average annual flow of a fresh water river, or withdraw water from an estuary, ocean, or Great Lake, must meet the impingement mortality and entrainment standards. Facilities that withdraw water from non-Great Lakes or take 5 percent or less of a freshwater river’s average annual flow only have to meet the impingement mortality standard.
Facility must submit a 316(b) Comprehensive Demonstration study with their next NPDES permit renew application or within 3.5 years of the Phase II rules are published in the *Federal Register*, whichever is the later date. This study contains substantial amounts of information on the hydrology and biology of the source water, the intake and cooling water system, and the proposed method of meeting the performance standards. Notable information requirements include:

- delineation of the intake’s zone of hydraulic influence
- detailed description of the taxa and life stages of fish and shellfish in the source water including spatial and temporal characteristics
- quantitative description of current impingement mortality and entrainment
- designs, drawings, and calculations to support the proposed impingement mortality and entrainment reductions
- a verification monitoring plan

Facilities that meet their applicable performance standards by reduce their cooling water intake rate to that commensurate with closed-cycle cooling or reducing through-screen velocity to no more than 0.5 fps, do not have to conduct a Comprehensive Demonstration Study.

**POSSIBLE TECHNICAL COMPLIANCE OPTIONS**

Several general strategies can be used to reduce or offset impingement mortality and entrainment:

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1 As of June 25, 2004, the Phase II regulations had not been published in the *Federal Register*. 
• minimize water withdrawal rate
• keep fish and shellfish away from the intake screens
• reduce mortality at the intake screens
• relocate intake away from fish and shellfish
• replace impinged and entrained fish and shellfish

The choice of technical compliance option will depend largely on the ambient conditions at the location of the intake and the layout of the power plant. Some options may not be physically capable of being located at some sites and others may be excessively costly. Each power station will have to be analyzed individually to determine the optimal solution.

Minimize Withdrawal
Cooling Towers Existing facilities can satisfy the performance standards for impingement mortality and entrainment reduction by converting from open-cycle to closed-cycle cooling – in other words – retrofitting with cooling towers. This measure would reduce water withdrawal by roughly a factor of 20, thereby reducing the number of fish and shellfish of all life stages exposed to the intake by roughly 95 percent. If the original intakes are used, impingement impacts would be further reduced because through-screen velocity would also be lowered.

Although cooling towers themselves are not particularly expensive items compared to the cost of a power plant, this option will not be the most economical for most facilities because of other associated costs. In many cases, long distances of large diameter pipe will be needed to reach the cooling towers, connecting to the existing condenser could be difficult and expensive because of limited space, and considerable generation time could be lost in the switch over. Plant auxiliary power systems many also have to be upgraded to power the fans in the tower, which would permanently reduce the net output of the power plant. The efficiency of the power plant’s cooling system could also be reduced resulting in additional decline in net power output. Retrofitting cooling towers is likely a viable option only for plants that also face derating to comply with water quality standards for discharge temperature.

Variable Speed Pumps In some cases, where fish have predictable daily or seasonal movements, using variable speed pumps to reduce intake rates at certain times of day or year may reduce impingement. If the timing of intake rate reductions, however, did not correspond with times of decreases in electrical demand, then the cost of lost generation over the life of the facility could be prohibitive.

Keep Fish Away
Behavioral Avoidance Barriers Numerous measures have been devised to behaviorally dissuade fish from approaching intakes such as diversion vanes, bubble curtains, strobe light systems, and sonic or electric fields. These methods typically have relatively low capital cost and moderate operation and maintenance costs, but they tend to be less reliable than physical barriers and are only applicable for reducing impingement. Most research on behavior barriers seems to have been done on salmonids and the effectiveness of these methods on warm water species is not well known.

Physical Barriers Block nets, fabric filter barriers, or porous dikes can provide a physical barriers to exclude fish and shellfish from the area in front of an intake. Block nets are and inexpensive way to excluding juvenile and adult fish but maintenance can be high in areas of high debris and sediment loads that can inhibit flow through the barrier and where high ambient flows and large debris could cause significant damage. Fabric filter barriers, such as the Gunderboom® Marine Life Exclusion System, can meet the requirements for reducing impingement and entrainment. This system has an air burst cleaning mechanism but strong currents, large debris, and boat or barge traffic could be a problem. A significant consideration regarding the feasibility of filter fabric barriers is that the low flow through rate per unit area could require barriers that are impractically long. Porous dikes can also meet the
requirements for reducing impingement and entrainment and are more resistant to currents, wave, ice, and large debris than fabric filter barriers. Dikes, however, are more expensive to install and can require a significant amount of space, which may be lacking in rivers where commercial navigation exists. Plugging of porous dikes can also occur over time depending on the ambient sediment load.

![Gunderboom® filter barrier](image)

**Reduce Mortality at the Intake Screens**

*Fish Handling and Return System* Intake traveling screens can be retrofitted with a fish handling system that will reduce impingement mortality. In these systems, troughs (fish buckets) are attached to the screens that provide areas of refuge for fish from the rapid flow of water though the screens. As the screens rotate, fish in the buckets are lifted out of the intake well and gently washed out of the troughs into a dedicated fish chute that gently returns the fish to the source water. Some existing traveling intake screens are likely suitable for modification with a fish handling system by adding fish buckets and fish spray systems to the existing screens. Many system, however, may not have enough headspace to accommodate the modifications and replacing the existing traveling screen system with new screens equipped with a fish handling system may be the most economical approach. To be most effective, the screens would have to be operated continuously. Considerations for this option include capital cost, operating costs, and downtime for installation. In cases where the flow-through velocity is relatively low, equipping a traveling screen with fine mesh (e.g. 1 to 2 millimeters), wedge-wire screen panels could make the system compliant for entrainment reduction. Because the fine-mesh screens have a relatively low percent open area, the acceptability of the final through-screen velocity would be a key specification.
**Fish handling and return system**

*Low Through-Screen Velocity* Impingement mortality can also be minimized by reducing the through-screen intake velocity and using wedge-wire screens. A through-screen velocity of 0.5 fps is widely regarded as sufficient to prevent the great majority of fish from becoming impinged and is specified by EPA as a design standard under the 316(b) rules for new facilities and as best technology available for meeting the impingement mortality reduction standard in the Phase II rules. Wedge-wire is trapezoidal in cross-section and is oriented on the screen with the wider of the parallel sides facing out. This arrangement presents a relatively flat surface to potentially impinged organisms and makes escape from the screen easier. Achieving the 0.5-fps through-screen velocity will require significant modification to most intakes to enlarge the screen surface area. Options include constructing a new completely new intake, adding new intake bays to an existing intake, replacing flow through screens with dual flow screens, or replacing flat screens with barrel screens, which have a larger surface area to volume ratio. Barrel screens may not be appropriate where they could interfere with or be damaged by commercial navigation. In addition to the capital costs, the cost of lost generation during construction and/or switch-over should also be considered.
Relocate Intake Away from Fish

Cooling water intakes are frequently located on the shorelines of water bodies. These shallow water habitats are also typically the most biologically active. Many species of fish spawn in these waters and the naturally occurring physical structures that generally exist along shorelines (e.g., fallen trees, submerged vegetation, undercut banks) provide cover for many game and forage fish species. Moving an intake to an offshore, deepwater location, where habitat complexity and fish densities are lower, could reduce the number of fish exposed to impingement or entrainment. A possible configuration of a new intake in this location would be a wedge wire, barrel screen or velocity cap. Because off-shore locations may present few constraints on size, these structures could be designed to have a through-screen velocity of less than 0.5 feet per second. This solution could be contraindicated if an intake structure at the new location would pose a danger to or could be damaged by navigation. In source water bodies with high ambient flow, installing a deep water, mid-stream intake could also be technically challenging. In addition to the capital cost of the new intake, plant downtime while switching over to a new intake should also be factor to consider in evaluating this 316(b) compliance measure.

Replace Impinged Fish

Stocking In some cases, the least expensive method for complying with the proposed Section 316(b) will be to mitigate for the losses rather than to avoid impacts. One option is to monitor impingement mortality and entrainment and arrange for the affected fish and shellfish to be replaced with fish and shellfish from a hatchery. The possibility exists that not all fish killed by the power plant would have to be replaced if some of that mortality consisted of non-native species or species that are considered over-abundant or undesirable. Fish stocking would be dependable but would also incur monitoring and stocking costs for the life of the facility.

Habitat Restoration Impingement mortality and entrainment could also be offset by restoring a nearby area of degraded habitat to increase the productivity of the impacted species and life stages. This option would be most
feasible if the cooling water intake is located in a water body that has a substantially degraded habitat. The U.S. Army Corps of Engineers (Corps) has programs devoted to habitat restoration. The possibility exists that a habitat restoration projects for 316(b) compliance could be turned over to the Corps for design, construction, maintenance, and monitoring with funding provided by the electric generating company. Such an arrangement would relieve the power utility of considerable responsibility. Of all the possible 316(b) compliance measures, habitat restoration may be the most risky in terms of success. No one can say, for instance, how many acres of habitat restoration will be required to mitigate for a given amount of impingement mortality or entrainment. Because of this uncertainty, considerable long-term monitoring is expected with this option with the possibility that additional restoration could be required if the initial attempt was insufficient.

CONCLUSION

Every existing electric generating facility that is subject to the new Section 316(b) Phase II rules is unique; therefore, the compliance approach that is most effective for one facility may not be for another. Given the number of compliance alternatives available, choosing the best option can be challenging given the number of factors to consider. Burns & McDonnell recommends conducting an initial feasibility study that considers physical relationship between the facility and its cooling water source, constraining environmental factors, and the cost of the compliance option in terms of capital, operation and maintenance, and long-term impacts on plant performance.